TENERA Environmental

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To: Paul Hurt, AES Huntington Beach

CC: Steve Maghy, AES; Shane Beck, MBC; Dave Bailey, EPRI Solutions

From: John Steinbeck

Re: Additional Information on HBGS Intake Velocity Cap Studies

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The Santa Ana Regional Water Board staff has indicated their interest in obtaining more information on the velocity cap studies conducted at HBGS. The new Phase II Rule allows for the use of data from historical studies to characterize baseline levels of impingement mortality and entrainment if the data can be shown to have been collected using appropriate methods and quality assurance.

The velocity cap at HBGS was installed during construction of the plant after results from model studies for HBGS and full-scale tests at the El Segundo Generating Station (ESGS) showed that a velocity cap would be effective in reducing impingement. The model studies were done using a 16 inch pipe in a 5 ft x 7 ft tank and showed that even small fishes that could avoid being pulled into the pipe when a velocity cap was in place were pulled into the pipe when the velocity cap was removed. These model studies were followed up by full-scale tests at the El Segundo Generating Station (ESGS) where impingement from July 1956 through June 1957 prior to velocity cap installation was compared with impingement from July 1957 to June 1958 after the velocity cap was installed. Total impingement between the two periods was reduced from 272.2 to 14.95 tons, a reduction of 95%. The results of the both the model studies and the full-scale tests at ESGS were presented in the Proceedings of the American Society of Civil Engineers (Weight 1958). The shortcomings of this study were that data on species composition were not available and the comparison was between two periods of several months during which fish composition could change. Therefore, there is some uncertainty related to the contribution of these differences to the reduction in impingement observed when the velocity cap was present.

The second study done in 1979-1980, was much more extensive and was carried out by a team of researchers from the University of Washington College of Fisheries. This study, which was summarized in the HBGS Proposal for Information Collection, may be the most comprehensive evaluation of velocity cap effectiveness ever conducted. This study collected impingement and source water data on individual species and the results were reported in several University of Washington technical reports (see references). The results were also published in an IEEE journal (Thomas and Johnson 1980). The hydroacoustic methods used as one of the approaches for sampling the source water fish populations were presented at a Scientific Committee on Oceanic Research (SCOR) meeting in 1980 (Thorne 1980).

The study consisted of a series of field trials at four different power plants over a year, with the majority of the trials at HBGS. The seven trials at HBGS resulted in 123 hourly estimates of impingement and source water fish abundances with 70 observations at full flow with the velocity cap in place. This was the control condition and was used to compare impingement and source water abundances under several other plant operating conditions. Source water abundances of fishes were estimated using hydroacoustic sampling that was supplemented with net sampling to verify the composition of the acoustic targets. Gill nets were also positioned at different depths in the water column to determine the vertical distribution of the different species. Data were collected with the plant under full operation in reverse flow (without velocity cap). Although the plant now rarely operates under full load, the flows used in the study would be the maximum possible under present conditions.

A smaller number of test runs were also done during the study to compare entrapment and vulnerability at full and reduced flow. Vulnerability was decreased under reduced flow conditions, but the reductions were not significant for white croaker and northern anchovy.

The study had several unique features that improved the ability to measure the effectiveness of the velocity cap. First, unlike the 1950s study, test conditions were evaluated for a few hours or days and then changed to evaluate another set of test conditions. This insured that fish composition and source water abundances didn't change dramatically between tests. Secondly, the intake tunnels were cleared of fishes between observations by injecting chlorine at the upstream end of the screenwell in concentrations that forced the fishes towards the traveling screens. This insured a complete count of fish entrapment during each trial. In addition, several trials of each test condition were conducted over the course of the study to ensure that seasonal differences in ocean conditions and fish composition were taken into account. Finally, the entrapment data were combined with estimates of source water fish populations in the vicinity of the intakes to calculate estimates of entrapment vulnerability. The source water population estimates were made using net and hydroacoustic sampling. This enabled the effects of the velocity cap to be evaluated independently of offshore population abundances. The statistical technique for adjusting the entrapment rates was to calculate the ratio of entrapment to fish densities in the source water in the vicinity of the intake (E/B). This ratio was used to estimate the relative vulnerability of fishes to entrapment by the intake. All of these study measures greatly improved the ability of the study to evaluate the effectiveness of the velocity cap and produced a study that would be very difficult to improve upon.

The use of the vulnerability ratio (E/B) in assessing differences among treatments had additional benefits that increased the statistical power to determine if there was a significant decrease in the vulnerability of fishes to impingement in the control condition with the velocity cap. The ratio of vulnerability resulted in a measure that adjusted the impingement data for the abundances of fishes in the source water during each observation to insure that any differences in impingement were the results of the presence or absence of the velocity cap and not source water abundances. This decreased the variation among observations within a treatment, which contributed to the ability to detect differences among treatments. The use of the E/B ratio and the large number of replicates of each treatment increased the statistical power of the study to detect any differences due to the velocity cap.

The final report presents results both for total impingement of all fish species combined (**Table 1**) and three individual fishes: queenfish, white croaker, and northern anchovy. Similar to the period of study in 1979 and 1980, queenfish and white croaker were the most abundant fishes in the impingement sampling done from July 2003 through July 2004, and northern anchovy was the fourth most abundant species. These three species accounted for almost 85 percent of the total impingement during the 2003-2004 period presented in the most recent studies. The recent IM&E report also included appendices with data and analyses for other fishes that were identified in the report as important for 316(b) studies. Except for silversides, these thirteen other species were collected in relatively small numbers. There were also large numbers of silversides collected, but they were mostly collected in the source water sampling, and were only collected from impingement sampling during reverse operations in the absence of the velocity cap. Although not analyzed in the report due to the absence of normal operations data for comparison, the results for silversides are a good example of the effectiveness of the velocity cap. Results showed that silversides were primarily distributed in the surface layers where they were less likely to be pulled into the system during normal operations with the velocity cap. In the absence of the velocity cap the intake draws water vertically from surface layers resulting in greater impingement of silversides.

The vulnerability ratios from the study present a more accurate measure of the true effectiveness of the velocity cap (**Figure 1**). As is clear from **Figure 1** the difference in vulnerability for Treatment 2 (full flow without the velocity cap) and Treatment 3 (full flow without the velocity cap) was highly significant which was verified by analyzing the data with a one-tailed Mann-Whitney U-Test ($p < 0.0001$).

In summary, it is appropriate that AES use the results from the 1979-1980 velocity cap studies in calculating a credit for HBGS baseline levels of impingement mortality for the following reasons:

- The use of data from the 1979-1980 velocity cap study is consistent with the new 316(b) rule, which allows the use of historical data in baseline calculations.

- The study was well designed and was probably the most extensive evaluation ever conducted on the effectiveness of velocity caps in reducing impingement mortality.
- The study was conducted by independent researchers from the University of Washington, and the results were published in a professional journal and presented at a scientific conference.
- The study would be extremely difficult to repeat today, due to the permitting requirements for the destructive sampling methods used for the source water populations and the chemical methods (chlorine injections) used to clear the tunnels of fishes between hourly observations.
- The study collected data on both impingement and source water abundances. This allowed impingement abundances to be adjusted so that the results reflected differences due to the presence or absence of the velocity cap and not source water abundances.
- The three species analyzed in detail were identified as key species because they comprised very large percentages of the total impingement. These three species were also identified from the recent impingement mortality study in 2003-2004 as comprising a very large percentage of total impingement. The Rule, in terms of the calculation baseline, requires making estimates for the species most susceptible to impingement and these three species at HBGS have been documented in the 2003-2004 as the most susceptible species.
- The results of the 1979-1980 study were consistent with the overall results of an earlier comparison from 1957-1958 such that the effectiveness of the velocity cap has been determined to meet the impingement mortality performance standard in two independent studies.
- Results for silversides from the 1979-1980 study show how the velocity cap functions in reducing impingement, and can result in the large decreases observed in total impingement during the 1957-1958 study.

The results from the 1979-1980 study clearly meet the requirements of the new 316(b) rule for use as historical data, and provide a much more accurate assessment of the effectiveness of the velocity cap than any study that could be conducted under current plant operating and regulatory conditions. Therefore, the average reduction of 82% from that study should be used as a credit towards meeting the Phase II performance standard for reducing impingement mortality by 80-95% as recommended in the HBGS PIC.

Table 1. Entrapment densities for total fishes at the HBGS during the 1979 and 1980 Velocity Cap Studies (from Thomas et al. 1980, Table 3, p. 18).

Year	Velocity Cap Present	Time	Entrapment Density (kg/hr)	Effectiveness
1979	No	Day/Night 18-hr	20.45	
1979	Yes	Day/Night 18-hr	1.97	90%
1979	No	Night	32.93	
1979	Yes	Night	15.53	53%
			Average:	**72%**
1980	No	Day	47.2	
1980	Yes	Day	0.65	99%
1980	No	Night	52.99	
1980	Yes	Night	6.78	87%
			Average:	**93%**
			Overall:	**82%**

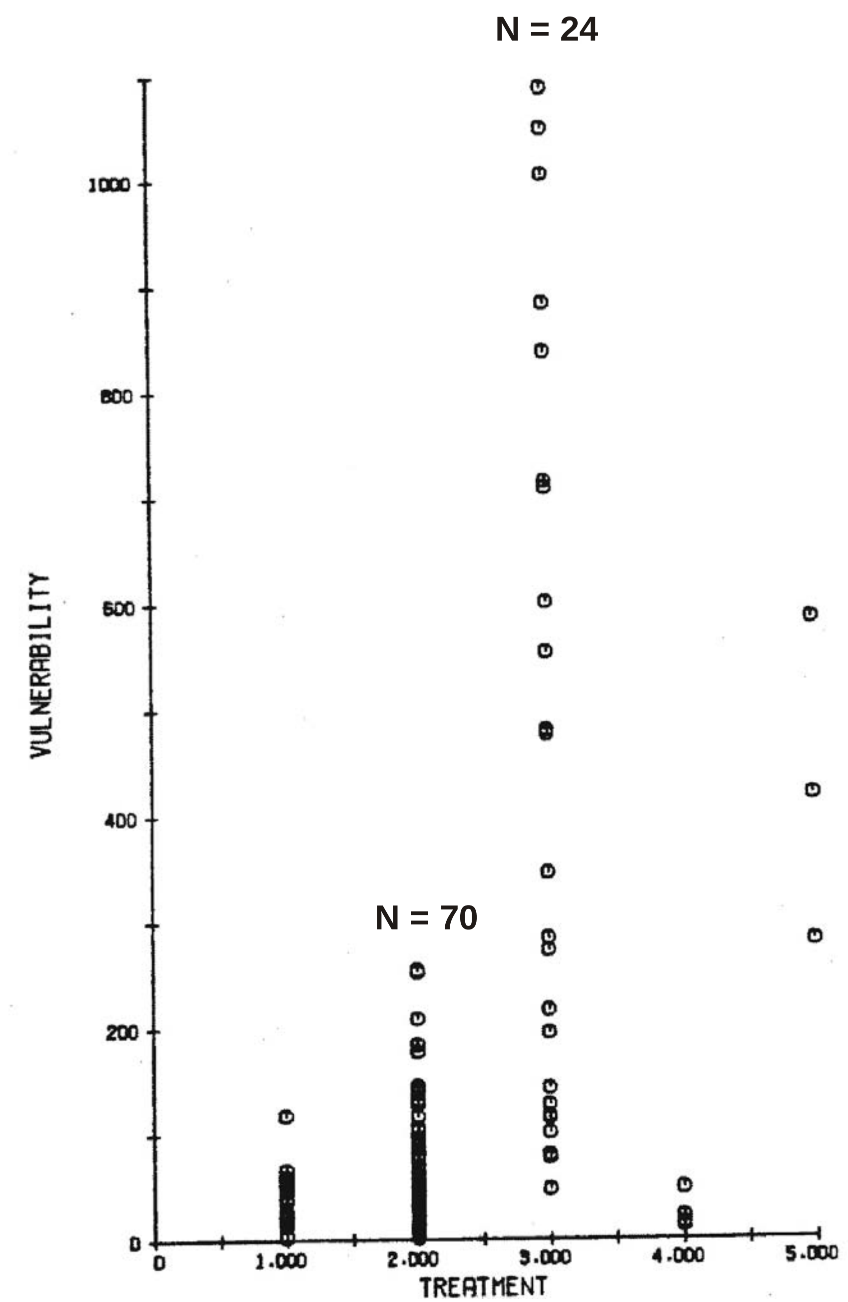

Figure 1. Vulnerability (E/B x 10^4) for all species combined by treatment (plant operational mode: 1 = reduced-flow with-cap; 2 = full-flow with-cap; 3 = full-flow without-cap; 4 = reduced-flow without-cap; and 5 = tunnel swapping, i.e., the transition period between reversed and normal flow directions). The data were collected at Huntington Beach in 1979 and 1980 (from Thomas et al. 1980 Figure 6 p.14).

Reports on Velocity Cap Studies at HBGS (chronological)

Weight, R. H. 1958. Ocean cooling system for 800 MW power station. Journal of the Power Division, Proceedings of the American Society of Civil Engineers. Paper 1888. Presented at the 1958 ASCE Convention.

Thomas G. L., L. Johnson, R. E. Thorne, and W. C. Acker. 1979. Techniques for assessing the response of fish assemblages to offshore cooling water intake systems. University of Washington College of Fisheries Fisheries Research Institute Report FRI-UW-7927. Prepared for Southern California Edison. 97 p + appendices.

Johnson L., G. L. Thomas, R. E. Thorne, and W. C. Acker. 1979. 7928 A field evaluation of the effect of nighttime flow reduction on entrapment of fish. University of Washington College of Fisheries Fisheries Research Institute Report FRI-UW-7928. Prepared for Southern California Edison. 26 p + appendices.

Johnson L., G. L. Thomas, R. E. Thorne, and W. C. Acker. 1980. A field examination of the effectiveness of a velocity cap in minimizing entrapment. University of Washington College of Fisheries Fisheries Research Institute Report FRI-UW-8003. Prepared for Southern California Edison. 29 p + appendices.

Thomas G. L., L. Johnson, R. E. Thorne, T. B. Stables, and W. C. Acker. 1980. A field evaluation of the recirculation of cooling water on the entrapment of fish at Huntington Beach generating station. University of Washington College of Fisheries Fisheries Research Institute Report FRI-UW-8012. Prepared for Southern California Edison. 44 p + appendices.

Thomas G. L., L. Johnson, R. E. Thorne, and W. C. Acker. 1980. A comparison of fish entrapment at four Southern California Edison Company cooling water intake systems. University of Washington College of Fisheries Fisheries Research Institute Report FRI-UW-8023. Prepared for Southern California Edison. 61 p + appendices.

Thomas G. L., R. E. Thorne, W. C. Acker, and T. B. Stables. 1980. The effectiveness of a velocity cap and decreased flow in reducing fish entrapment. University of Washington College of Fisheries Fisheries Research Institute Report FRI-UW-8027. Prepared for Southern California Edison.

Thomas, G. L. and R. L. Johnson. 1980. Density Dependence and vulnerability of fish to entrapment by offshore-sited cooling water intakes. Oceans IEEE Journal. 15:504-508.

Thorne, R. E. 1980. Assessment of population abundance by echo integration. SCOR Working Group 52. Presented at Symposium on Assessment of Micronekton.